

NASA Electronic Parts and Packaging (NEPP) Program – Update

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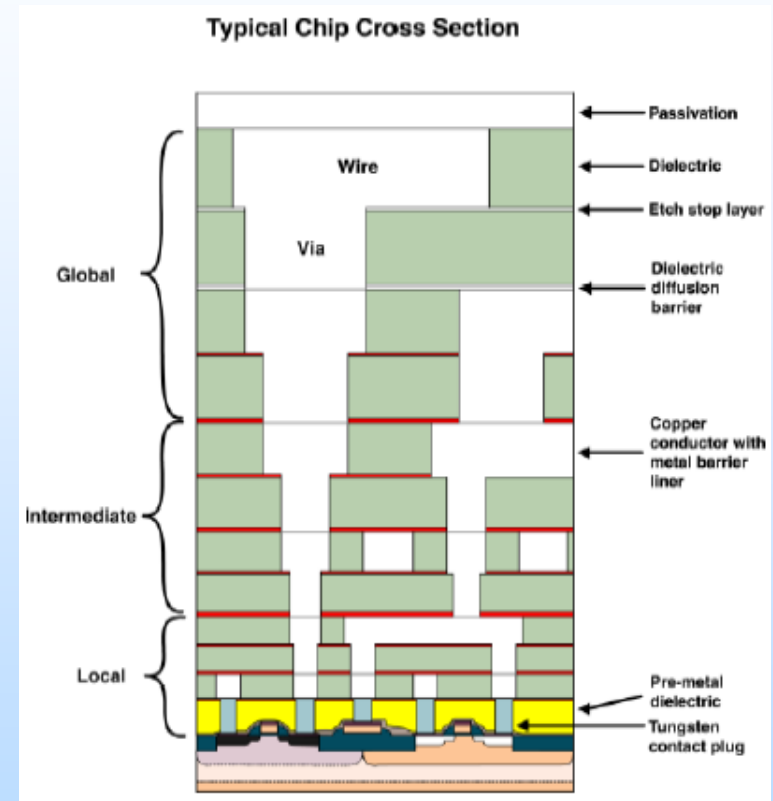
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Co- Managers NEPP Program

<http://nepp.nasa.gov>

NEPP Mission

- The NEPP mission is to provide guidance to NASA for the selection and application of microelectronics technologies, to improve understanding of the risks related to the use of these technologies in the space environment and to ensure that appropriate research is performed to meet NASA mission assurance needs.



NEPP Overview

- NEPP supports all of NASA for >20 years
 - 7 NASA Centers and JPL actively participate
- The NEPP Program focuses on the reliability aspects of electronic devices
 - Three prime technical areas: *Parts (die), Packaging, and Radiation*
- Alternately, reliability may be viewed as:
 - Lifetime, inherent failure and design issues related to the electronic parts technology and packaging,
 - Effects of space radiation and the space environment on these technologies, and
 - Creation and maintenance of the assurance support infrastructure required for mission success.

*Electrical overstress failure
in a commercial electronic device*





NEPP Works Two Sides of the Equation

- Assurance
 - *Issues that are applicable to space systems being designed and built (i.e., currently available technologies)*
 - Examples
 - Cracked capacitors
 - DC-DC converter reliability
 - Enhanced Low Dose Rate Sensitivity (ELDRS)
 - Communication infrastructure via website and working groups
 - NASA Electronic Parts Assurance Group (NEPAG)
 - Audit and review support
- New electronics technology
 - *Issues that are applicable to the next generation of space systems in conceptualization or preliminary design*
 - Examples
 - 45-90 nm CMOS
 - SiGe
 - State-of-the-art FPGAs
 - Collaboration with manufacturers and government programs for test, evaluation, and modeling
 - Development of new predictive performance tools

NEPP Supports the Industry

- **NEPP has close, cooperative and long-standing relationships with government and non-government entities worldwide**
 - Large university involvement
 - Close ties to many DoD/DOE agencies
 - International collaboration with JAXA, ESA, CNES, and others
 - Support for many working groups, organizations, and technical meetings including
 - G12, JEDEC, SPWG, IEEE NSREC and RADECS, IMAPS, SEE Symposium
 - NEPAG weekly telecons (1 International per month)
 - *New: bi-monthly radiation telecons with ESA!*
 - Test and insertion guideline development
 - Consortia memberships
 - CALCE, CAVE, and AVSI
 - Leading effort for new QML (Y) for non-hermetic packaged devices
- ***NEPP provides unique capabilities within NASA***
 - *Evaluate technologies in advance of mission needs*
 - *Provide assistance with risk management of technology insertion*



NEPP Has a Wide Range of FY10 Efforts



- **Tasks vary extensively in the technologies of interest**
 - Building blocks like capacitors
 - Standard products like DC-DC Converters, linear bipolar devices, and A-to-D Converters
 - New commercial devices such as FPGAs and memories
 - Test structures on emerging commercial or radiation hardened technologies
 - Specialized electronics such as IR arrays and fiber optics
 - New assurance methods and investigations
- **A few samples follow highlighting points of contact (note: this is not an exhaustive list)**

Many of the tasks (radiation, in particular) are in conjunction with other government agencies

Task Area: Complex Active Electronics

- *Memories*



Memories are considered major bottlenecks in current space system development (processors, data storage, configuration areas for FPGAs).

NEPP's goal is to enable insertion of new, higher performance devices into systems by understanding risk and providing qualification guidance.

Reliability

(parts, packaging)

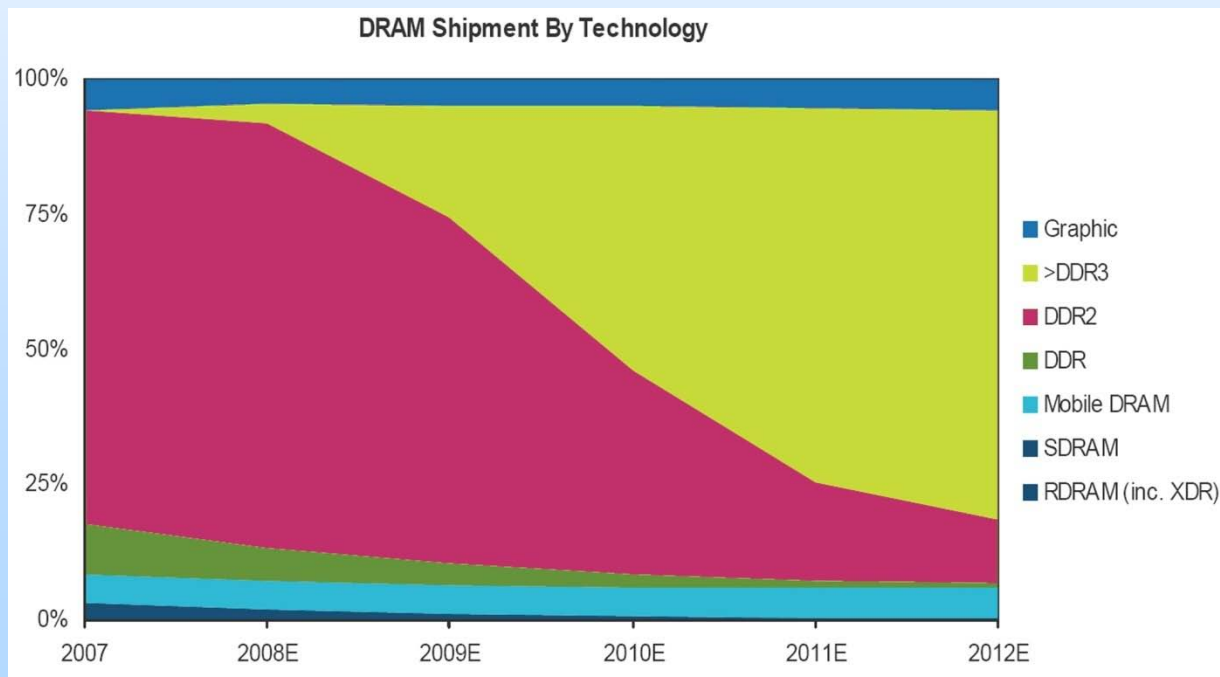
- **Flash Memory Reliability**
 - Jason Heidecker, JPL
- **SDRAMs**
 - Subtask under emerging CMOS
 - JPL
- **Combined Effects**
 - Tim Oldham – Dell/NASA-GSFC

Radiation

- **Flash memory hardness**
 - Tim Oldham, Dell/NASA-GSFC
 - Farohk Irom, JPL
- **Phase change memory**
 - Ken LaBel, NASA-GSFC
- **SDRAMs**
 - Ray Ladbury, NASA-GSFC
- **Alternate architecture and technology memories**
 - Jonathan Pellish, NASA-GSFC

The SDRAM Quandary

- Many space designs are baselining/using DDR and DDR2 interfaces for hardware builds
 - Problem: **DDR3 expected to dominate commercial product starting in 2010!**
- Do we support current system designs or product development timelines?
 - Will DDR2 be obsolete by system readiness dates?



Task Area: Complex Active Electronics

- *Systems on a Chip (SOCs)*



SOCs are rapidly being inserted in NASA systems. This includes FPGAs, multi-core processors, and associated area array packages.

NEPP's goal is to understand risks associated with new FPGAs, etc. and developing qualification guidance where none exists.

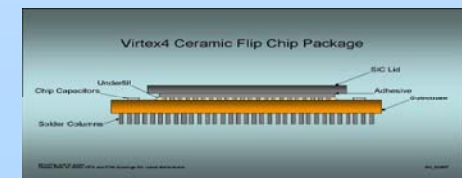
Reliability

(parts, packaging)

- **FPGA Reliability**
 - Doug Sheldon, JPL
- **Xilinx Virtex-IV Package**
 - Amin Mottiwala, JPL
- **Area Array Packages and Solder Failures**
 - Reza Ghaffarian, JPL
- **Area Array Package Model Development**
 - Mark Strickland, NASA-MSFC

Radiation

- **FPGAs**
 - Melanie Berg, MEI/NASA-GSFC
 - Greg Allen, JPL
- **Multi-core/SOC Processors**
 - Steve Guertin, JPL
 - Ken LaBel, NASA-GSFC
 - Effort is collaboration with OGA on MAESTRO Program
 - NASA-wide study support of multi-core insertion



Task Area: Complex Active Electronics

- *Data Conversion Devices*



Analog to digital converters (ADCs) are used in all forms of on-board space data collection. New, higher performance ADCs and their partners (DACs) have entered the market. These enable our instrumentation. NEPP's goal is to develop appropriate test techniques and evaluate these new devices.

Reliability

(parts, packaging)

- No current effort underway

Radiation

- ADC Test Methodology Development
 - Melanie Berg, MEI/NASA-GSFC
 - Continue development of Single event test techniques to provide system designers improved information for usage
 - Evaluate emerging state-of-the-art ADCs for viability
 - DACs are TBD
- ADC Architecture Intercomparison (TID)
 - Jonathan Pellish, NASA-GSFC



Task Area: Power

- *Power MOSFETs*

Power MOSFETs are critical components in distributing power in space systems. New radiation issues and vendors have surfaced.

NEPP's goal is expedite development of new test guidelines and evaluate new power MOSFETs as they enter the market.

Reliability

(parts, packaging)

- No efforts currently underway on power MOSFET/package reliability

Radiation

- Power MOSFETs Guideline Development and Test
 - Leif Scheick, JPL
 - Working w/ 1080 update and new ASTM method
- Power MOSFET SEGR Rate Prediction
 - Jean Marie Lauenstein, NASA-GSFC
 - Framework developed in FY10
- Testing is focused on all vendors developing space product



Task Area: Power

- *Power Converters*

New architecture power conversion systems are required to support emerging SOC power requirements (i.e., distributed lower voltage at device).

NEPP's goal is determine if existing DC-DC converter qualification methods are adequate and to evaluate new device types..

Reliability

(parts, packaging)

- **Point of Load (POL) Converter Body of Knowledge (BOK)**
 - John Shue, NASA-GSFC
 - Testing new Aeroflex architecture
- **POL Reliability Testing**
 - Rosa Leon, JPL

Radiation

- **POL Radiation Testing**
 - Dakai Chen, MEI/NASA-GSFC
 - Among others, we've supported testing of Intersil's new offering
- **DC-DC Converter Radiation Testing**
 - Anthony Sanders, NASA-GSFC

Task Area: Emerging Technologies



- Scaled CMOS

Modern commercial CMOS devices have scaled to the 45nm technology node. The current qualified rad-hard process node is 150nm. We use commercial parts with feature sizes less than 90nm.

NEPP's goal is to understand the risk associated with commercial CMOS processes and provide guidance for qualification and technology development.

Reliability

(parts, packaging)

- Scaled CMOS Reliability
 - Mark White, JPL
 - Collaborate with AVSI
 - SDRAMs as test vehicle
- Impact of TID on CMOS Reliability
 - Jonathan Pellish, Jill Walker, NASA-GSFC

Radiation

- Scaled CMOS Collaborations
 - Jonathan Pellish, Michael Xapsos, Kenneth LaBel, NASA-GSFC
 - Paul Marshall, Consultant
 - Working with multiple process foundries, universities, other government
 - See following chart
 - Radiation considerations for scaled CMOS
 - Proton single event test guide released in FY09
 - Vanderbilt University developing tools for modeling



CMOS Radiation Test Plans/Status - Partial

	<u>90 nm</u>	<u>65 nm</u>	<u>45 nm</u>	<u>Notes</u>
IBM		SOI and bulk SRAMs evaluated for SEE (proton and heavy ion)	SOI SRAMS received and SEE tests completed ; FY10 discussion on latch type structures	Collaboration with IBM and Sandia; 32 nm samples in the offing. Supports RHBD, trusted foundry, DTRA, ...
Texas Instruments	TID on transistors completed (90 and 130 nm)	SEU/SEL on SRAMs completed; Transistor TID tests completed.	SRAM Test Structures delivered and SEE tested; Vanderbilt test structures under test in FY10	Collaboration with TI and Vanderbilt; Experiments also performed at temperature
SIRF Program	TID on transistors completed	TID on transistors completed		Courtesy of Xilinx and AFRL; Experiments also performed with temperature
Intel		TID and dose rate completed	1st hi-K commercial device. TID and dose rate test completed. Parametric TID tests completed (report available through INTEL)	Collaboration with Intel and NSWC
ST Micro-electronics		Under discussion. Partially ESA supported.		Collaboration with ST



Task Area: Passives

- Capacitors

Capacitors are one of the most highly used components in space systems.

NEPP's goal is to evaluate capacitor types/technologies to determine appropriateness for space usage.

Reliability

(parts, packaging)

- High-power Tantalum Capacitors
 - Alexander Teverosky, Dell/NASA-GSFC
- Hand Soldering and FEA of Capacitors
 - Alexander Teverosky, Dell/NASA-GSFC
- TBD: Polymer or BME Capacitor Evaluation
 - David Liu, MEI/NASA-GSFC
- Capacitor Testing
 - Penelope Spence, JPL

Radiation

- None planned

Task Area: Actives

- *Linear devices*

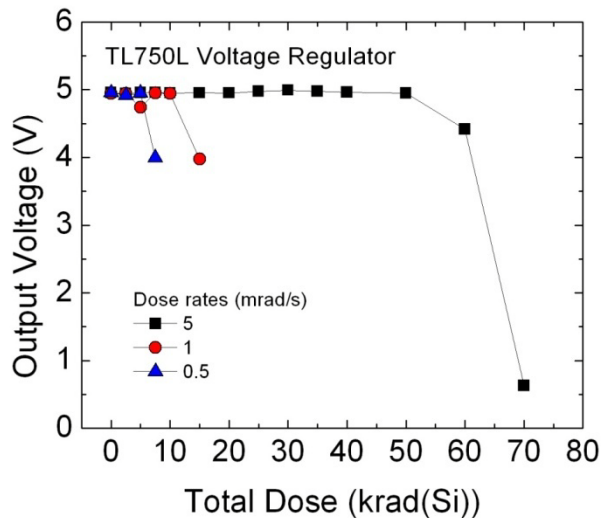
Linear bipolar and CMOS devices are prevalent in all space system designs. Radiation issues related to enhanced low dose rate sensitivity (ELDRS) and transients are still critical to the industry.

NEPP's goal is to determine appropriate qualification risks and methods.

Reliability

(parts, packaging)

- None planned



Radiation

- Hydrogen's Effect on ELDRS
 - Philippe Adell, JPL
- Ultra-low dose rate experiments
 - Dakai Chen, MEI/NASA-GSFC
- Effect of TID on SET/SEU
 - Dakai Chen, MEI/NASA-GSFC

Task Area: Specialty Electronics

- *Fiber Optics*



Fiber optics have reemerged as a promising technology for space use with four vendors developing “spaceflight” transceivers.

NEPP’s goal is to work with JEDEC on developing appropriate qualification guidelines and evaluate selected product.

Reliability

(parts, packaging)

- JEDEC JC13.6 Support
 - Melanie Ott, NASA/GSFC
 - Charles Barnes, JPL
- Evaluation of AVIM Termini
 - Melanie Ott, NASA/GSFC
- BOK
 - Charles Barnes, JPL

Radiation

- None planned (fund limited)

Task Area: Specialty Electronics



- Other

Electronics such as sensors, cryogenic, and SiGe are used extensively in space systems.

NEPP's goal is to work selected topics were appropriate to maximize a minimum of available funds.

Reliability

(parts, packaging)

- **Cryogenic Electronics Evaluation**
 - Richard Patterson, NASA/GRC
- **RF Electronics BOK**
 - Rosa Leon, Jason Skinner, JPL

Radiation

- **Commercial SiGe Evaluation**
 - Paul Marshall, Consultant
 - John Cressler, Georgia Tech
- **IR Sensor Lessons Learned**
 - Cheryl Marshall, NASA/GSFC
- **Cryogenic Radiation Latchup**
 - Cheryl Marshall, NASA/GSFC
 - In collaboration with an IR&D effort



Task Area: Radiation Assurance

- *Model and Tool Development*

The tools we require for determining mission risk have fallen behind the technology insertion curve.

NEPP's goal is to close this gap.

Reliability

(parts, packaging)

- AVSI, CALCE, and CAVE work previously shown

Radiation

- CRÈME-MC
 - Robert Reed, Vanderbilt University
 - Continuing development of Monte Carlo-based single event prediction tool
 - NEPP develops technology models and works to properly validate the toolset
 - FY10 focuses on approach for commercial complex devices in addition to designing hardened devices
 - FY11 Power MOSFET development planned



Summary

- **NEPP has a wide range of efforts on-going**
 - Only a portion were described here
- **NEPAG was on only touched on**
 - Infrastructure for the agency and the industry
 - Audits, SMD reviews, new technology reviews
 - Existing electronics FA
 - Weekly working groups, and so on
- **We value our partners**
 - Other agencies
 - Industry
 - University
 - International
- **Visit the NEPP website for more!**
 - <http://nepp.nasa.gov>